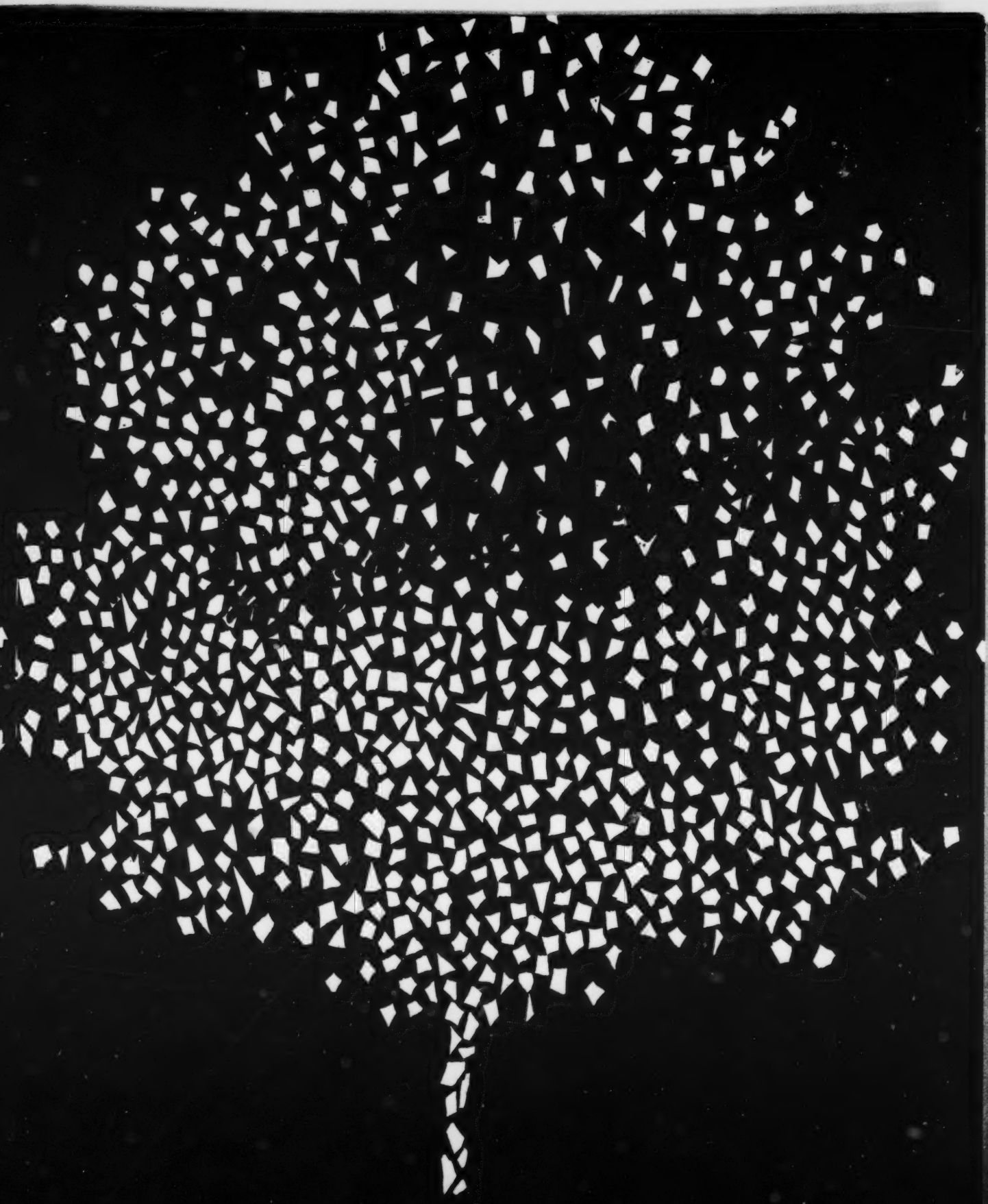

Wood Chip Drying Seminar

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WOOD CHIP DRYING SEMINAR

This is a report of the Wood Chip Drying Seminar sponsored by Energy Secretariat and Research and Productivity Council of the Province of New Brunswick.

This Seminar was organized as part of the EnerOptions Program of the Energy Secretariat, and further information on the sessions can be obtained from:

EnerOptions Seminars and Workshops
Forests, Mines and Energy
P. O. Box 6000
Fredericton, N.B.
E3B 5H1

Sincerely,

E. T. Owens

E. T. Owens
Manager
Wood Energy Program
Chairman
Wood Chip Drying Seminar

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SUMMARY

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Research and Productivity Council
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A seminar to explore state-of-the-art systems and methods in wood residue drying was held November 7, 1985 at Woodstock and Lakeville in western New Brunswick. There were 45 participants representing industry, government and university and they spent the morning discussing the technical developments of chip drying. In the afternoon a detailed tour was made of a chip drying project, thus providing an application of the morning presentations.

The objectives of the Seminar were to:

1. identify state-of-the-art drying developments and their applications;

2. report preliminary results of a commercial chip drying project and

3. establish future activity in drying.

The Seminar was part of the Wood Energy Program and was organized under the aegis of the New Brunswick Energy Secretariat and Research and Productivity Council. The attendance was limited purposely to selected participants who had reasonably direct interest in wood residues and thus would concentrate the discussion on the specifics of residue drying. Geographically, the participants were from Maine and Atlantic Canada with one each from Quebec and Ontario.

At the conclusion of the site tour of P.C. Toft's drying project as is customary with the ENEROPTIONS programs, each participant was requested to complete an evaluation of the seminar. The summary of these evaluations showed that participants benefitted from the content of the Seminar, and that they would have liked to spend more time in group discussions.

ECONOMICS OF RESIDUE DRYING

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Neill & Gunter Ltd.
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INTRODUCTION

The ENFOR PROJECT C-96, Cost Benefit Analysis of Systems Using Flue Gas or Steam for Drying of Wood Waste Feed Stock by C. MacCallum, B. R. Blackwell, L. Torsein; October, 1981 is a comprehensive review of the subject, and I would recommend it to anyone who is contemplating the installation of a wood fuel drying system.

BACKGROUND

Why would we consider drying wood fuels? Is drying economical? To answer these questions we must start with an understanding of the nature and composition of wood fuels, the combustion process and furnace design.

1. Wood Fuels

A sample of wood fuel will contain water (moisture) and dry solids. The moisture content of wood fuels varies widely, depending on the source of the fuel and the method of storing it. Moisture contents on a wet basis can range from 15% for kiln dried residues to 70% for saturated bark. The moisture content of fresh or green wood chips would normally range from 45% to 55%.

A standard analysis of the dry solids in wood fuel will show that it is composed of:

H_2	6%
C	52%
O_2	40%
Ash	2%

Approximately 70% of the dry matter is volatile and 28% is fixed carbon, with the balance being ash.

The dry solids in a typical wood fuel will have a heat content or calorific value of approximately 20 Mega Joules per kilogram (8700 BTU per lb.).

2. Combustion

In a furnace, combustion or "burning" of wood fuels can be split into four processes which take place in different zones on and above the furnace grate, namely:

1. Heating and drying of the fuel.
2. Pyrolysis of the dried fuel resulting in carbon and gas.
3. Combustion of the pyrolysis gas.
4. Final combustion of the carbon.

Combustion itself may be defined as the rapid chemical combination of oxygen with the combustible elements of a fuel. The combustion reactions are exothermic, i.e. they generate heat. In wood fuel there are two chemical elements of significance to the combustion process - carbon and hydrogen. Air is the usual source of oxygen for the combustion.

3. Furnace Design

The primary function of a fuel burning system is to provide controlled, efficient conversion of the chemical energy of the fuel into heat energy which is then transferred to heat absorbing surfaces. A fuel burning system is an interconnection of devices which appropriately prepares fuel and air for combustion, properly directs their introduction into the furnace, provides conditions for stable ignition and combustion, suitably removes the products of combustion from the furnace and transfers the maximum possible amount of heat energy to the heat absorbing surfaces of the furnace.

The objective in designing a fuel burning system is to arrange heat transfer surface and fuel burning equipment in such a manner as to optimize thermal efficiency and economic benefit.

A simplified diagram of a fuel burning system is shown in Figure 1.

Effects of Fuel Moisture

So what does this all mean? The key is moisture and its effect on the design, efficiency and operation of the burning system. Moisture in the wood fuel affects:

- System efficiency
- Power consumption of ancillaries
- Capacity to generate heat
- Air pollution
- Use of auxiliary fuel
- Ease of operation

1. System Efficiency

Wood fuel moisture content affects the system efficiency in two ways. First, it decreases the effective heating value of the fuel, as energy is required to evaporate the water. Figure 2 illustrates the relationship between wood moisture content and heat lost with water vapour in the stack gas.

Secondly, as wood moisture content increases, the amount of excess air must be increased to help dry the fuel on the furnace grate. An increase in the amount of excess air decreases the efficiency as shown in Figure 3.

Figure 4 indicates how the overall system efficiency is affected by the moisture content of the wood fuel.

2. Power Consumption

Combustion air and flue gas quantities passing through the boiler increase as the moisture content of the wood fuel increases. This results in greater power consumption by the forced draft and induced draft fans. It also increases the size of these fans, the flue gas ducts, and the furnace itself, all of which has a direct effect on capital costs of the system.

3. Capacity to Generate Heat

The rate of combustion of wood fuel increases somewhat with an increase in combustion zone temperature and increases considerably with a decrease in fuel moisture content. It is suggested that the rate of combustion is controlled by the rate of diffusion of water vapour from the wood particles and/or the rate of diffusion of oxygen and combustion products.

Where heat energy production is limited by heat transfer surface and by the rate that the wood fuel will burn in the furnace, a decrease in fuel moisture content will significantly increase heat energy production. Figure 5 illustrates this effect for one particular boiler.

4. Air Pollution

When drier wood fuel is burned, emissions of unburned particulate are considerably reduced. The lower particulate emission is due to more complete combustion, resulting from the high rate of combustion, and a longer residence time in the combustion zone.

5. Auxiliary Fuel Use

Ease of Operation

One of the benefits of drier wood fuel is that the furnace is easier to operate. It is more stable and can respond quicker to changes in demand. This is because the wood fuel burns more quickly. Consequently, the use of auxiliary fuel for load stabilization can be minimized.

6. Summary

Improvements in boiler performance which result from a reduction in wood fuel moisture content are:

1. Increased steam generating capacities.
2. Increased boiler efficiency.
3. Lower power consumptions for FD and ID fans.
4. Higher combustion zone temperatures.
5. Increased combustion efficiencies.
6. Reduced particulate emissions.
7. Reductions in consumption of auxiliary fuels.
8. Improved stability of boiler operation.
9. More rapid response to load changes.

Economics of Drying

From the preceding sections we can see that when some of the moisture is removed from the wood fuel before it enters the furnace, less energy is consumed in the furnace itself to evaporate the water from the fuel and less excess air is required to help dry the fuel on the furnace grate. However, this reduction in energy consumption must be kept in perspective by considering the furnace and dryer as a unit. More significantly, a decrease in the moisture content of the fuel considerably increases the rate of combustion of the wood fuel in the furnace.

This leads then to considering how we can reduce the moisture content of the wood fuel and what are the specific economic benefits of drying the wood fuel.

1. Types of Dryers

Wood fuels can be dried using the following categories of dryers:

a. Dryers using boiler flue gases in direct contact with the wood fuel.
   - Rotary dryers
   - Cascade dryers
   - Flash dryers

b. Dryers using steam indirectly to dry the wood fuel.
   - Indirect -steam dryers
   - Steam/hot air dryers

A simplified diagram of a flue gas dryer is shown in Figure 6.

The specifics of these various drying systems are discussed in the ENFOR report and by other speakers, and I will only address the relative economics of these various types in combination with the furnace.

2. Dryer Applications

In the ENFOR study, four boiler sizes were chosen for an economic comparison of the benefits of wood fuel drying. For each size of boiler, two general cases were considered:

1. The economics of purchasing a new boiler and dryer together.
2. The economics of adding a dryer to an existing boiler.

In each of the two general cases, four types of dryers were considered. The economic comparison included the total installed cost of the system, the operating costs such as wood fuel purchased, oil savings, electrical power costs and gross payback time.

In all cases an initial fuel moisture content of 55% was used.

3. New Boiler and Dryer Installations

The capital cost estimates for a combination of a new boiler and dryer are shown in Table 1.

The net annual operating savings, increase in capital cost and gross payback time for new boiler and dryer installations are presented in Table 1. The base case is a new boiler sized to produce its rated capacity without a dryer. The addition of a dryer would reduce the size and total cost of the boiler itself, but it would increase the total overall capital cost.

In this general case a dryer is not attractive, because the boiler itself can be designed to produce the heat energy required by burning enough wet hog fuel, using little or no auxiliary fuel. The wood fuel savings that could be realized by drying would not justify the net incremental cost of the dryer, unless wood fuel were extremely expensive or the supply limited.

Table 1

Summary of Capital Cost Estimates,

New Boiler and Dryer Installations, Total Plant Cost Installed

Alternative	Total Amount, Material + Labour, $ X 1000			
	130 MW	65 MW	40 MW	15 MW
Boiler With No Dryer	29,700	18,100	12,800	7,200
Boiler With Rotary Dryer	31,600	18,750	13,650	8,000
Boiler With Cascade Dryer	33,100	19,800	14,200	7,600
Boiler With Flash Dryer	31,600	19,100	13,700	8,500
Boiler With Indirect-Steam Dryer	34,800	20,900	15,000	8,600
Boiler With Steam/Hot Air Dryer	34,400	20,300	14,700	8,100

Table 2

New Boiler and Dryer Installations

Alternative	Boiler Size (MW)			
	130	65	40	15
Boiler With No Dryer				
Operating Cost	Base	Base	Base	Base
Capital Cost	Base	Base	Base	Base
Boiler With Rotary Dryer				
Net Op. Cost Savings - $X1000/yr	87	42	26	8
Capital Cost Increase - $X1000	1900	650	850	800
Gross Payback Time - Years	21.8	15.5	32.7	100
Boiler With Cascade Dryer				
Net Op. Cost Savings - $X1000/yr	65	31	18	5
Capital Cost Increase - $X1000	3400	1700	1400	400
Gross Payback Time - Years	52.3	54.8	77.8	80

Boiler With Flash Dryer

Net Op. Cost Savings - $X1000/yr		(43)	(21)	(13)	(2)
Capital Cost Increase - $X1000		1900	1000	900	1300
Gross Payback Time	- Years	Negative	Negative	Negative	Negative

Boiler With Indirect - Steam Dryer

Net Op. Savings - $X1000/yr		291	143	86	39
Capital Cost Increase - $X1000		5100	2800	2200	1400
Gross Payback Time	- Years	17.5	19.6	25.5	35.9

4. Retrofit Dryer Installations

The capital cost estimates for a dryer system retrofitted for an existing boiler are shown in Table 3.

The net annual operating savings, capital costs and gross payback times for dryers retrofitted to an existing boiler are presented in Table 2. It is assumed that the increased heat energy output from the boiler would displace fossil fuel.

In this general case a retrofitted dryer can be very attractive where a portion of the heat is presently supplied from fossil fuel or when an increased heat energy output is required without using additional fossil fuel.

Table 3

Summary of Capital Cost Estimates,

Existing Boiler and Retrofit Dryer Installations,

Total Plant Cost Installed

Alternative	Total Amount, Material + Labour, $ X 1000			
	130 MW	65 MW	40 MW	15 MW
Boiler With Retrofit Rotary Dryer	5,300	2,800	2,200	1,600
Boiler With Retrofit Cascade Dryer	6,450	3,750	2,700	1,400
Boiler With Retrofit Flash Dryer	10,600	6,200	4,800	3,500
Boiler With Retrofit Indirect - Steam Dryer	13,600	7,800	6,000	3,400
Boiler With Retrofit Hot Air Dryer	7,100	3,600	2,750	1,500

Table 4

Existing Boiler and Retrofitted Dryer

Alternative		Boiler Output (MW)
Boiler With No Dryer		65
Boiler With Rotary Dryer		76
Net Op. Cost Savings	- $X1000/yr.	1,130
Capital Cost	- $X1000	3,200
Gross Payback Time	- Years	2.8
Boiler with Cascade Dryer		78
Net Op. Cost Savings	- $X1000/yr.	1,297
Capital Cost	- $ X 1000	4,300
Gross Payback Time	- Years	3.3

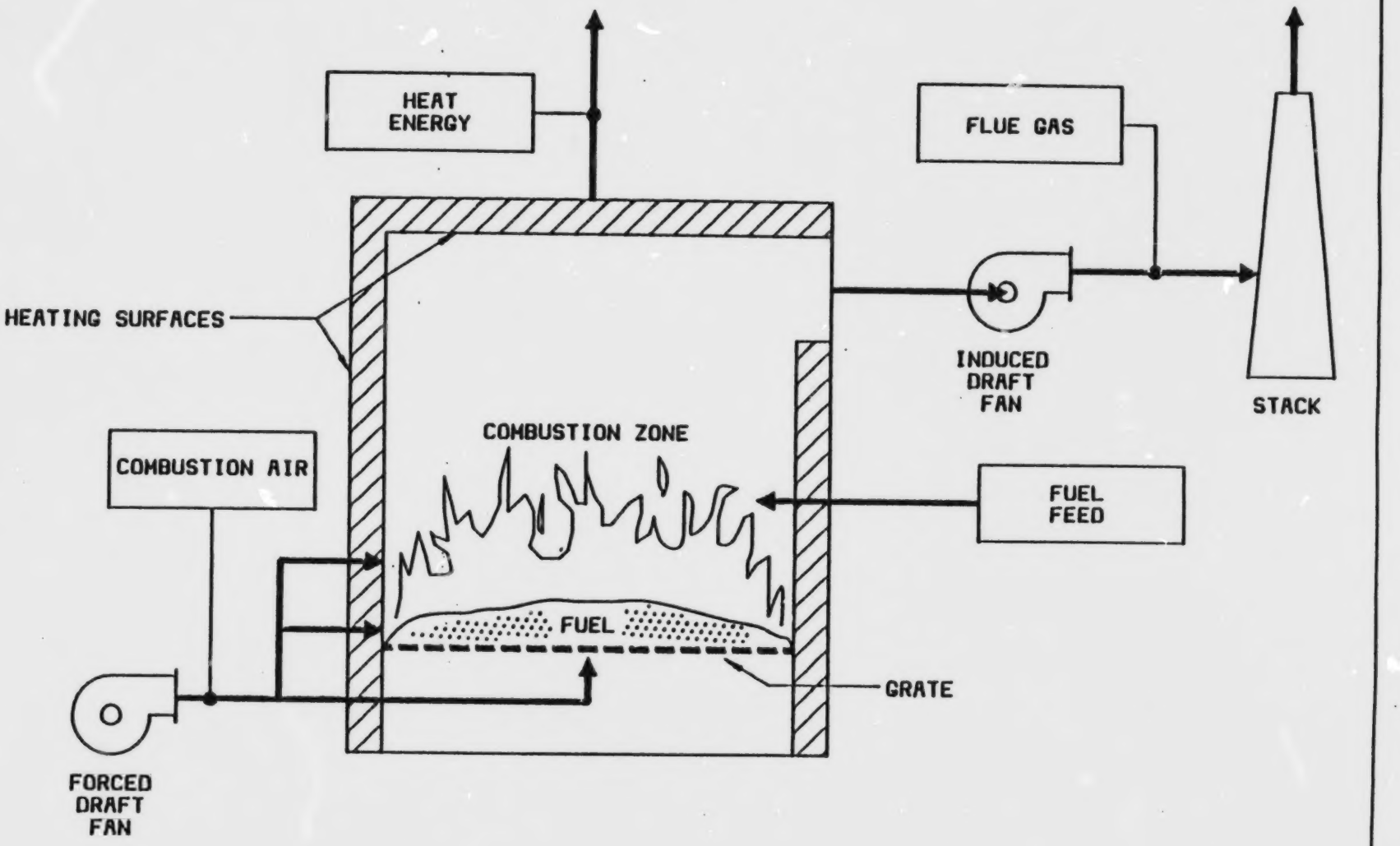
Boiler With Flash Dryer		165
Net Op. Cost Savings - $X1000/yr.	9,110	
Capital Cost - $ X 1000	12,970	
Gross Payback Time - Years	1.4	
Boiler With Indirect Steam Dryer		165
Net Op. Cost Savings - $X1000/yr.	9,534	
Capital Cost - $ X 1000	16,704	
Gross Payback Time - Years	1.75	
Boiler With Steam/Hot Air Dryer		76
Net Op. Cost Savings - $X1000/yr.	1,216	
Capital Cost - $ X 1000	4,200	
Gross Payback Time - Years	3.45	

In this review I have discussed only wood fuel dryers which are part of the furnace or boiler system. However, the technical advantages of fuel drying apply equally well to any type of dryer, in any location. In other words, off-site drying can also be considered. In this case the economic advantages of off-site drying must include the total energy and cost picture.

5. Summary

- Hog fuel drying systems can be categorized by their source of heat, as flue-gas dryers or steam dryers. There are three types of flue-gas dryers: rotary, cascade and flash. There are two types of steam dryers: the hot air dryer and the shell-and-tube dryer.

- The main benefit of hog fuel drying is that drier fuel burns faster. Hence, with drier fuel, there is potential to displace some of the fossil fuel burned in existing boilers, with hog fuel.
- Secondary benefits include improved thermal efficiency of the boiler system, improved ease of boiler operation and a substantial reduction in the emission of unburned particulate.
- Capital costs for a dryer associated with a boiler having a heat output of 65 MW after the installation of the dryer range from $2,800,000 for a rotary dryer to $7,800,000 for a shell-and-tube dryer.
- A dryer can be very attractive as a retrofit to an existing boiler where a reasonable portion of the heat is presently supplied from fossil fuel, or where there is the desire to increase steam production without using additional fossil fuel.
- A dryer is not attractive with a new boiler, because the boiler can be designed to produce the steam required by burning enough wet hog fuel, using little or no auxiliary fuel. However, provision should be made in the boiler design for the addition of a dryer if steam demand increases.
- In retrofit situations, hog fuel dryers can have payback periods of 1.5 to 3.5 years, but only if there is the potential to displace fossil fuel. A flash dryer would probably have the shortest payback time.
- An objective site-specific analysis of the technical, economic and engineering details is required to assess the attractiveness of installing a hog fuel drying system at a given mill and to select the most appropriate type of dryer.



FUEL BURNING SYSTEM

FIGURE 1

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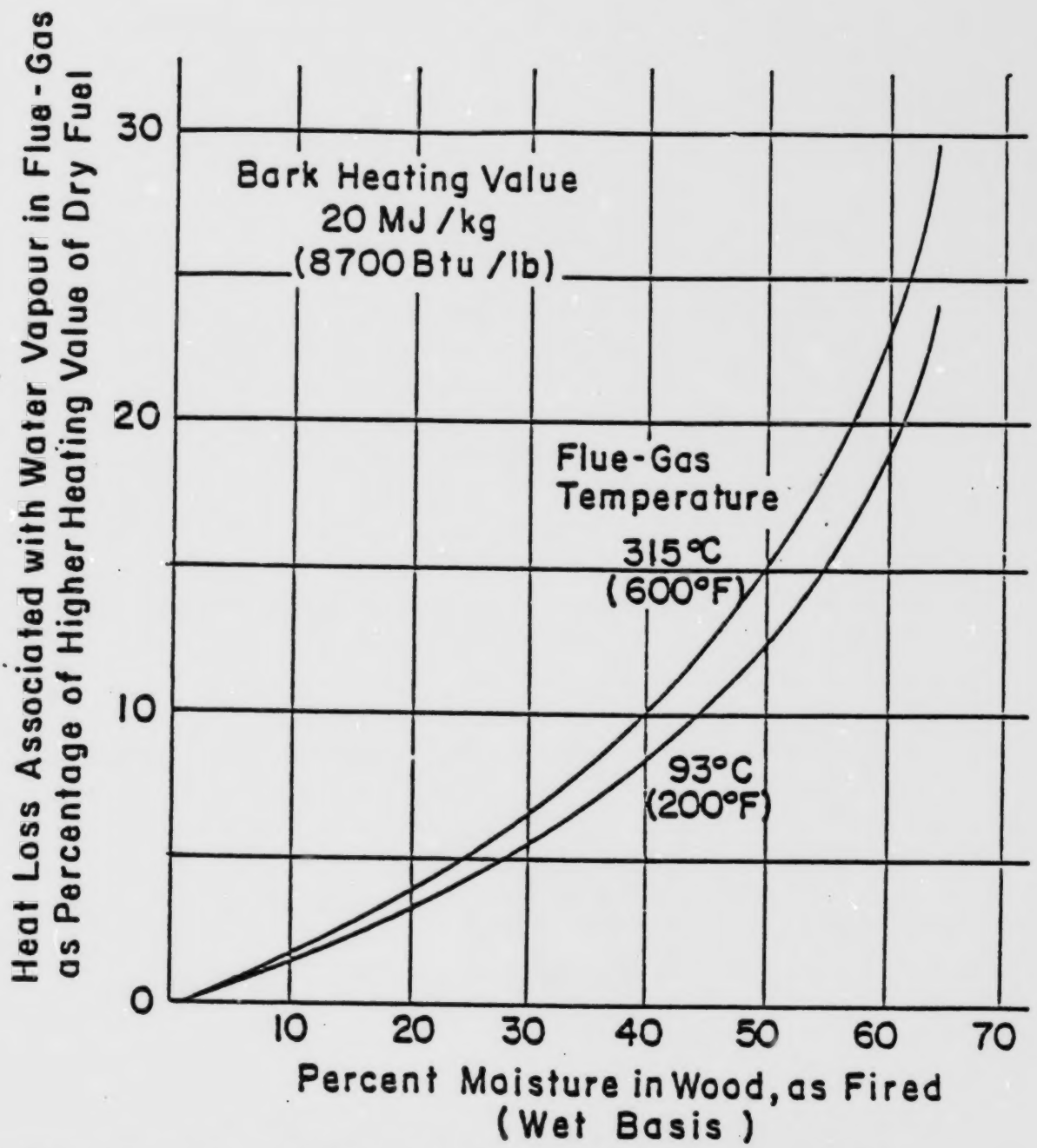


Figure 2 : Effect of Wood Moisture Content on Heat Lost with Water Vapour in Stack Gas.
(Miller and Hansen)

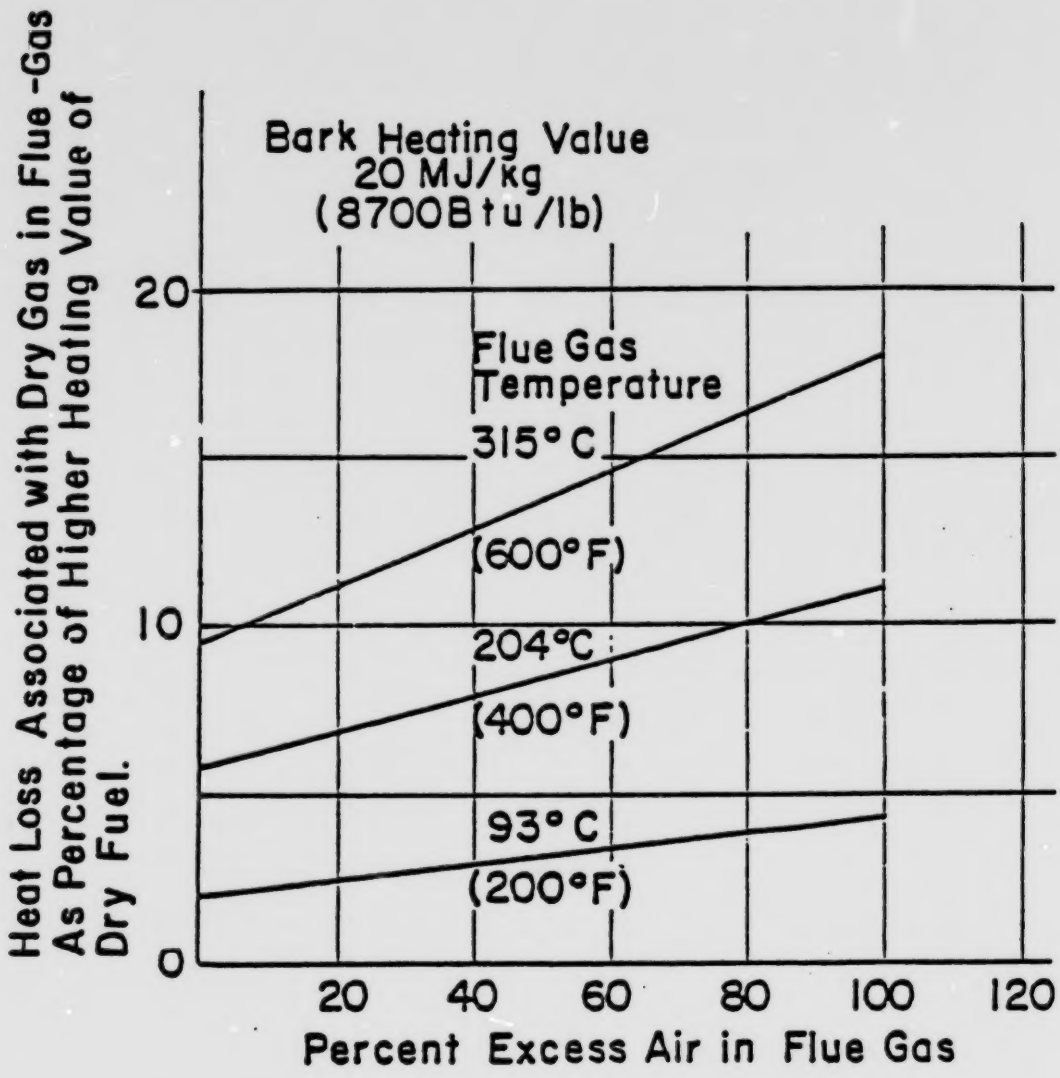
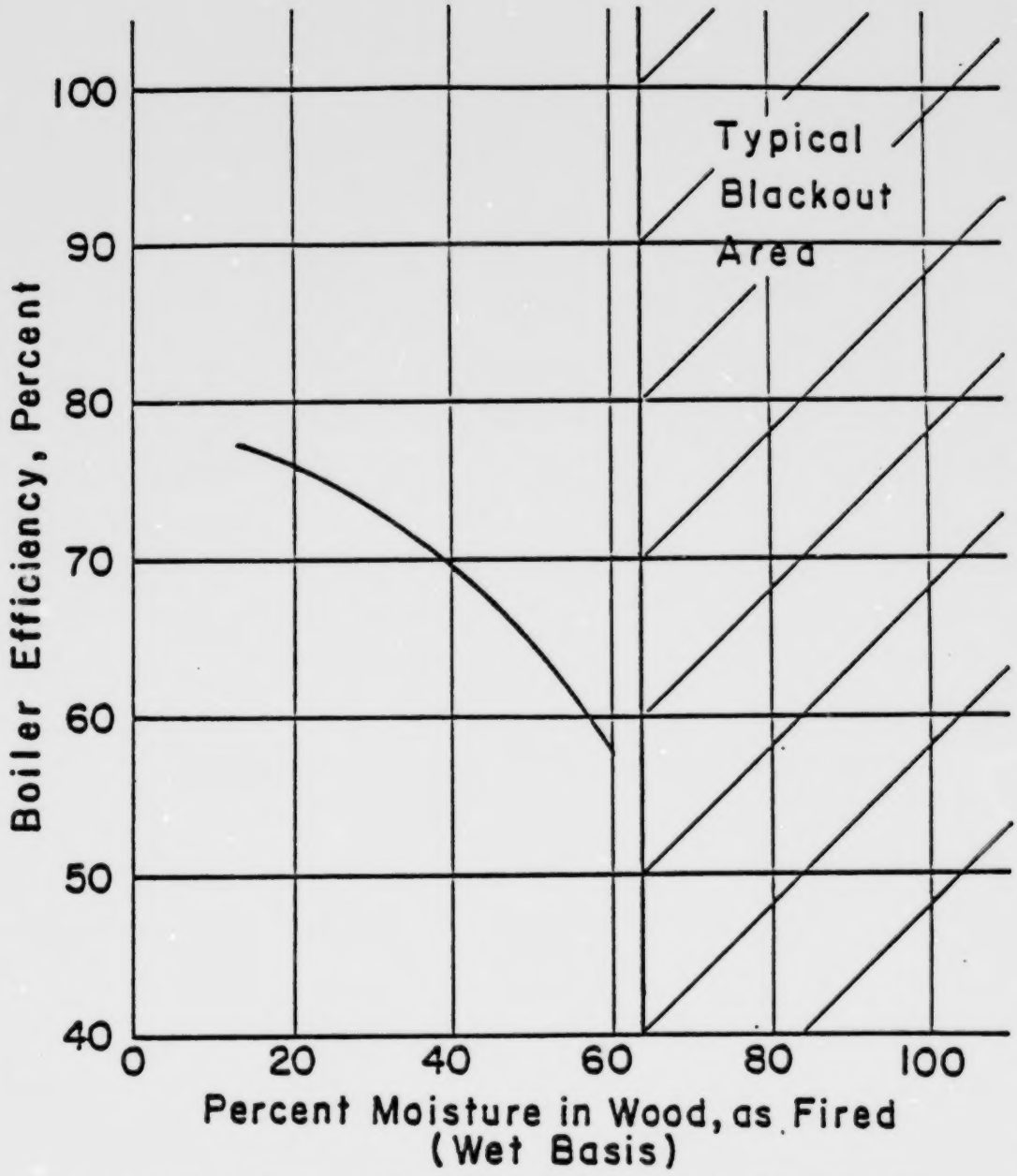


Figure 3 :Effect of Excess Air on Heat Lost with Dry Gas in Flue-Gas. (Miller and Hansen)



Basis: Higher Heating Value of 8750 Btu/lb for Wood and Bark, Stack Temperature 260°C(500°F), % Excess Air Equal to % Fuel Moisture.

Figure 4 : Effect of Wood Moisture Content on Boiler Efficiency
(R.L. Stewart)

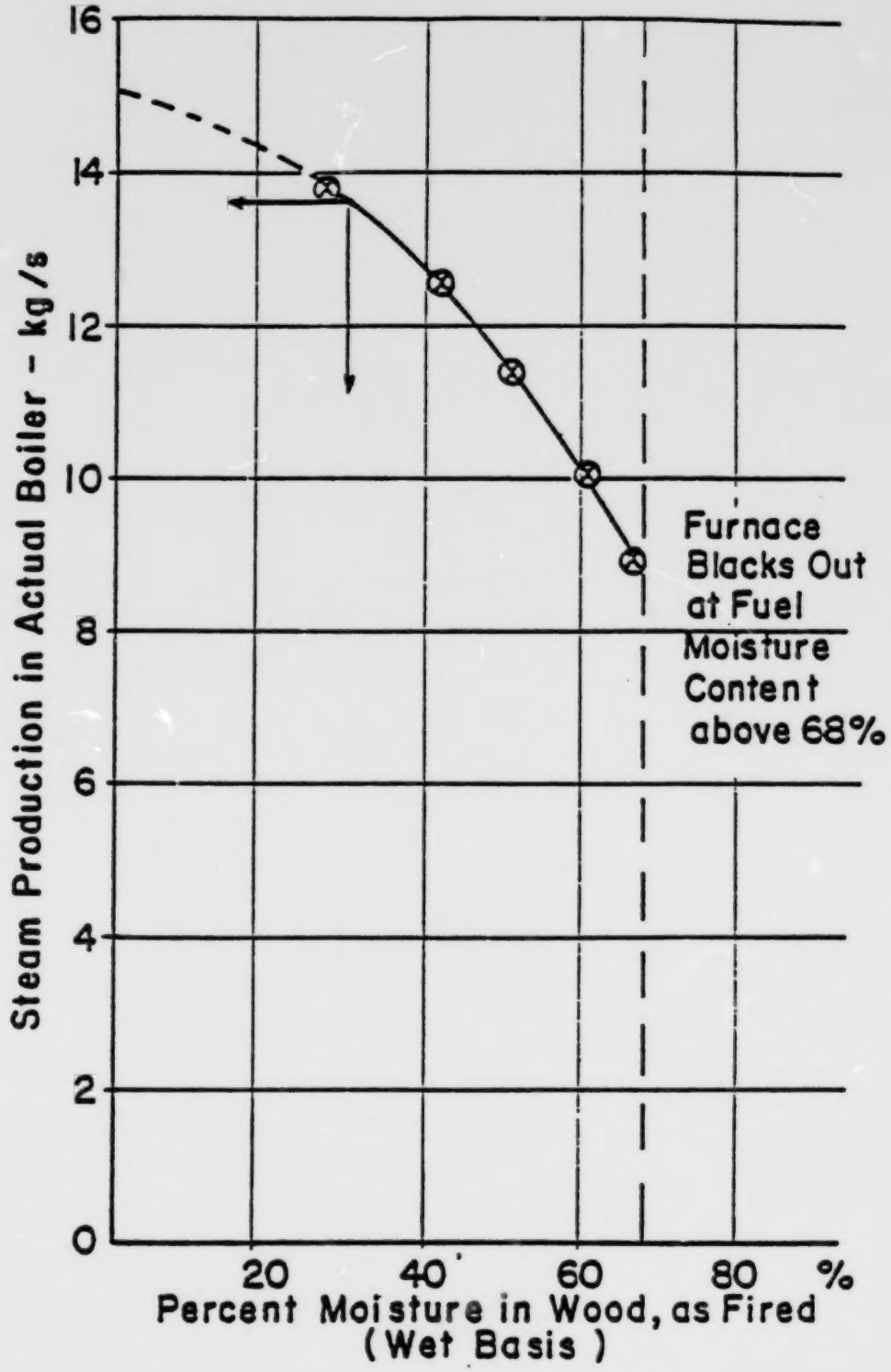
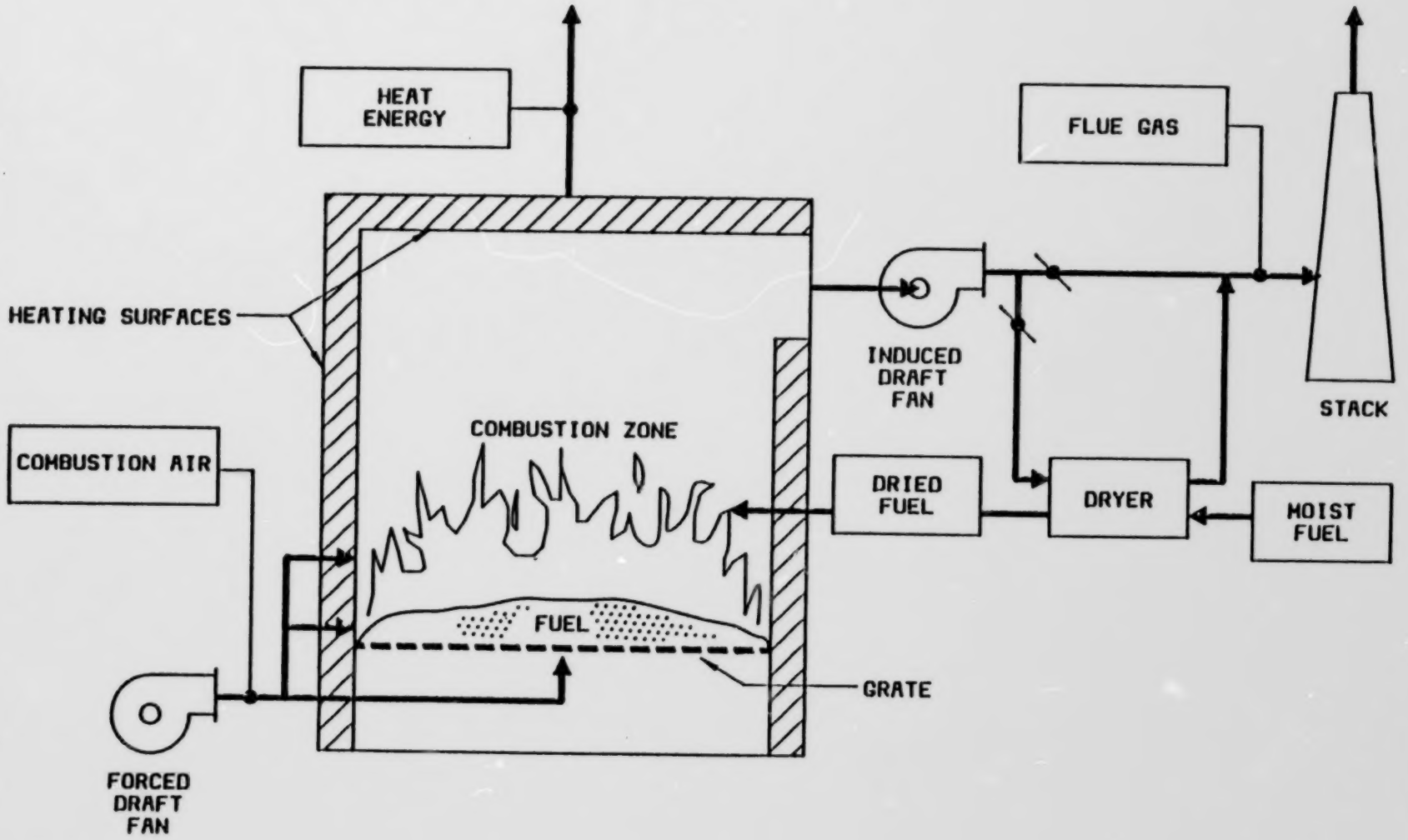


Figure 5 : Effect of Fuel Moisture Content on Steam Production. (R.C. Johnson)



FUEL BURNING SYSTEM

FIGURE 6

THERMAL DRYING IN PRACTICE

Stan R. Vuckovic, P.Eng.
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Over the last few years, the drying of hog fuel has become a necessity due to the favourable effects of drier fuel on boiler and furnace performances.

During this period, thermal drying systems have developed to dry wet fuel by using heat generated either from a direct or indirect heating system.

Among these systems, those most accepted and recognized by the Pulp and Paper Industry (From the point of view of the number of successful installations in the Industry) are the following types:

ROTARY DRYERS (SINGLE AND TRIPLE PASS)

CASCADE DRYER

FLASH DRYER

The thermal drying principle can be explained as a heat transfer from the flue gas to the wood particles. Once the wood particle is in contact with the hot gas its temperature starts to rise. If the particle is exposed to high temperature gases with a low wet bulb temperature (80°F) its surface moisture will be flash-dried as soon as the surface temperature exceeds the wet bulb temperature of the hot gas.

After the surface moisture is removed, the surface temperature of the particle will start to rise due to the lack of water evaporation to cool the surface. At temperatures of over 500°F, the organic materials will start to thermally break down and to show up as blue-white smoke in the exhaust gases. After a certain period of time the interior water will begin to evaporate and will eventually stop the formation of blue haze in the gases.

The problem of overheating the particle can be prevented by using low excess air with wet bulb temperatures (150-170°F). The boiler's exhaust gases usually have these characteristics, so the blue haze effect will not be present when used for drying hog fuel.

However, in a direct firing system, a recirculation system would be required to prevent the formation of such an effect.

The present practical applications of thermal drying in the industry for drying hog fuel to be used for generating energy could be classified as the following:

1) Drying hog fuel for gasification process where the final moisture content should be between 20 and 25% (wet basis).
2) Drying hog fuel for steam generation, where the final moisture content will depend on how the material will be burned in the boiler. If it is to be burned on the grate, the moisture content should be between 30 and 35%. If it is used for burning in suspension, the moisture content should be either 10 or 12%.
3) Drying hog fuel for wood densification process. In this case the final moisture content should be either 8 or 10%.
4) Drying hog fuel for generating heat either in lumber kilns or in waferboard and particle board dryers. The final moisture content will depend upon the type of furnace used. If a wet cell burner is used, the moisture content should be between 30 and 35%. If a suspension burner is used, the moisture content should be either 10 or 12%.

All three types of thermal drying systems can be used for the above mentioned thermal drying applications, depending upon the available heat energy in the drying gases, the quantity of wet fuel for drying and particle size.

However, the Pulp and Paper Industry should carefully select the thermal drying systems for their proper application. This is extremely important, since there is no reason to select a system with a long retention time for removing the surface moisture only. A system such as that is usually more expensive than a simple flash pre-dryer without a hammermill supplied. Also, it would be inappropriate to use a flash drying system complete with a hammermill for drying below 35% since this system requires a lot of electrical power to pulverize wet hog fuel and will be more costly than a rotary dryer.

The following example illustrates the importance of making the proper selection of a system:

This thermal drying application is based on drying 24 TPH of bark by using flue gases with a temperature of 425°F. The bark's initial moisture content is 60%. The dried bark will be used to generate 110,000 lbs of steam per hour.

The first system choice is a rotary single pass dryer. The drying system with its efficiency is able to reduce the moisture content down to 50% by using the boiler exhaust gases at 425°F. The total price of the system is $600,000 and it requires 240 HP, of which 200 HP belongs to the I.D. fan only.

The second system choice is a flash pre-dryer without a hammermill. The system is less efficient than the first, because the material final moisture content is specified as 53%. However, it is interesting to note that the price of this system is only $290,000 and requires only 125 HP.

So the Industry has the choice of getting a little bit more efficiency from the first system and paying 52% more for such a small difference in the moisture reduction, or buying the less efficient system and saving $310,000.

As far as the overview characteristics of each thermal drying system are concerned, the following description could be given:

- A rotary dryer is a cylinder rotating in a horizontal plane which acts as a heat exchanger for the uniform transfer of thermal energy from the hot gases to the hog fuel. These dryers are known as single and triple pass dryers, known to have large capacities, long retention time (single pass dryers only) and high evaporation rates. The single pass dryer can evaporate up to 40,000 lbs. of water per hour. It can also uniformly dry particles of various sizes.

As the name indicates, triple pass dryers have three tubes installed in one large rotary drum. These tubes provide the necessary retention time for the particles to be dried. Due to the small cross-section areas of the tubes, and to the high volume of gases required for this type of dryer, the conveying velocities are higher than those for single pass dryers. High conveying velocity increases the pressure drop across the dryer requiring more horse-power than single pass dryers. Also, triple pass dryers usually have lower drying capacities and provide a maximum evaporation rate of 38,000 lbs of water per hour.

The acceptable size of particles for rotary dryers is 2" X 1" X 1/4". They require 1300 BTU (during summer) and 1500 BTU (in winter) to evaporate a pond of water. Retention time of the particle into the single pass dryer is 20 minutes; as opposed to 1 to 2 minutes for the triple pass dryer.

The cascade dryer looks like a large cyclone in which hog fuel enters from the top of the cyclone and falls downwards where it is mixed with the boiler flue gases. The flue gases enter at the lower point of the dryer and produce a high turbulence required for the cascade effect inside the cyclone.

The mixture of gas and wet fuel travels upwards in the center of the dryer to the top, where the gases, now cooled, leave the dryer through the top and the hog fuel falls down for further drying.

When the hog fuel reaches the desired final moisture content, it is removed through an outlet classifier at the bottom of the dryer.

This type of dryer prefers a particle size of 2" or less and its retention time is only 2 minutes. According to the dryer manufacturer, it requires only 1167 BTU to evaporate one pound of water. It is valid only for a waste heat drying application.

The flash dryer consists of a series of vertical tubes. The hog fuel is fed into one tube and mixed with hot flue gases, which are used as both the transporting and the drying medium. The flue gases can be taken before or after an air heater and/or economizer, depending upon the desired final moisture content of the hog fuel.

After pre-drying, large pieces of hog fuel are pulverized in a hammermill to obtain dimensions of approximately 0.07 inches in diameter. These small particles go through a series of vertical tubes where the final drying is achieved through direct contact between flue gas and the particles. The dried particles are separated from the flue gases in a cyclone and transferred to the boiler for burning in suspension.

This system requires 1200 BTU to evaporate one pound of water for a waste heat drying application, and it has a retention time of only 30 seconds.

The capital cost of these thermal drying systems for a similar capacity can be classified as follows, starting with the least expensive system:

1)	Rotary Single Pass Dryer	$3,450,000.
2)	Cascade Dryer	$4,700.000.
3)	Flash Pre-drying System (Complete with a hammermill)	$6,750,000.

The above mentioned capital costs include installation, material handling, process controls, motors, ash handling, hog fuel drying system, ducting, ID fan dryer and dust collector. They have been taken from the report on the Cost Benefit Analysis of Systems Using Flue Gas or Steam for Drying of Wood Waste Feedstocks, which has been prepared by C. MacCallum, B. R. Blackwell and L. Torsein.

Based on the authors' experience, the capital cost of drying 50 TPH of wood waste from 50% down to 30% was $700,000 for a rotary single pass dryer and $1,200,000 for a flash pre-drying system complete with a hammermill.

Unfortunately, the detailed operating costs of the above mentioned systems are not available. However, it could be said that these systems require very little maintenance (except for the flash pre-dryer with hammermill) and most of them are made for automatic operation with little supervision necessary.

The most prominent present and future application of thermal drying systems will be within the Pulp and Paper Industry. This industry could become oil-free by burning dried hog fuel in their boilers for steam generation. The drying of hog fuel can be done without the need to supply additional energy required for the drying process, because energy could be recuperated from the boiler exhaust gases.

The improvements noted in boiler performance by using drier hog fuels are:

- increased steam generating capacities
- increased boiler efficiency
- lower power consumption for FD and ID fans
- higher combustion zone temperatures
- increased combustion efficiency
- reduced particle emissions
- reduced consumption of fossil fuels
- improved stability of boiler operation
- more rapid response to load changes

The following case of a drying system actually installed in the Industry could be used to illustrate the above-mentioned benefits of using drier hog fuel for steam generation.

A large Pulp and Paper mill in Nova Scotia installed a rotary single pass drying system, complete with hog fuel handling system. The dryer was designed to dry bark by using the boiler exhaust gases. The mill decided to buy the system, because it was very difficult to keep a stable combustion in the boiler without supporting half the required heat by burning oil.

The boiler steam output when fired with hog fuel was 190,000 lbs. of steam per hour. The quantity of wet bark available for steam generation was 58 TPH at 65% moisture content (wet basis). By burning the fuel in the wet condition, the boiler was able to produce 160,000 lbs. of steam per hour. The balance had to be generated by burning bunker "C" oil. It cost the mill over $2.4 million per year.

After adding the drying system to the boiler, the hog fuel moisture content was reduced from 65% down to 55% by using the boiler flue gases with a temperature of 390°F. Moisture reduction allowed the boiler to generate 190,000 lbs of steam per hour by using drier hog fuel only. The oil replacement savings provided a payback period of 2.5 years for the drying system. Also, the drying system helped the mill to reduce consumption of bunker "C" oil by 2,300,000 gallons annually.

We have seen all of the benefits of thermal drying of hog fuel prior to burning for steam and heat generation. The drying of hog fuel should no longer be considered a dilemma, since it has been shown to be a key factor in the over-all improvement of system efficiency and in making the Pulp and Paper Industry oil-free.

SELECTED MANUFACTURERS' LIST OF DRYING SYSTEMS

TYPE OF DRYING SYSTEM	COMPANY NAME	LOCATION	REPRESENTED IN CANADA BY:
• Cascade Dryer	BAHCO Industri AB	S-199 01 Enkoping, Sweden Tel: 0171/33200	Ross Pulp and Paper Inc. (A Hercules Company) 304 St. Patrick Street La Salle, Quebec Tel: (514)366-5160
• Flash Dryer	FLAKT Industri AB	Sweden	Flakt Canada Ltd. 1400 Merivale Road Box 5060, Station "F" Ottawa, Ontario K2C 3P9 Tel: (613)226-3300
• Flash Dryer	BISON-WERKE	Springe 1 D-3257 W. Germany Tel: 5041/711	G. & V. Ergon Inc. P. O. Box 637 Westmount, Quebec H3Z 2Y7 Tel: (514)488-8150
• Rotary Single Pass Dryer	Rader Companies	Portland, Oregon 97220 P. O. Box 20128 Tel: (503)255-5330	Rader Canada Ltd. 1200 Begin Street St. Laurent, Quebec H4L 1R1 Tel: (514)331-1200
• Rotary Single Pass Dryer	BISON-WERKE	Springe 1 D-3257 W. Germany Tel: 5041/711	G. & V. Ergon Inc. P. O. Box 637 Westmount, Quebec H3Z 2Y7 Tel: (514)488-8150
• Rotary Triple Pass Dryer	THE HEIL CO.	3000 W. Montana St. P. O. Box 593 Milwaukee, Wisconsin 53201, USA Tel: (414)647-3333	3000 W. Montana St. P. O. Box 593 Milwaukee, Wisconsin 53201, USA Tel: (414)647-3333

TYPE OF DRYING SYSTEM	COMPANY NAME	LOCATION	REPRESENTED IN CANADA BY:
• Rotary Triple Pass Dryer	BISON-WERKE	Springe 1 D-3257 W. Germany Tel: (5041)/711	G. & V. Ergon Inc. P. O. Box 637 Westmount, Quebec H3Z 2Y7 Tel: (514)488-8150
• Rotary Triple Pass Dryer	M.E.C. COMPANY	1402 W. Main Box 330 Neodesha, Kansas 66757, USA Tel: (316)325-2673	1402 W. Main Box 330 Neodesha, Kansas 66757, USA Tel: (316)325-2673

MECHANICAL DRYING - DEVELOPMENTS AND FUTURE

By Daniel Y. Guimier, P.Eng.
Forest Engineering Research Institute of Canada

Summary of Presentation

In addition to decreasing transport, handling and storage costs, substantial improvements in burner efficiency are achievable by drying wood fuel. As an example one tonne of wood fuel at 100% moisture content might only be equivalent to 0.9 barrel of bunker C oil worth $33, whereas one tonne of the same fuel with 25% moisture is equivalent to 1.6 barrels of bunker oil worth $60.

Moisture can be present in wood fuel in three different forms: (1) bound water in the cell walls; (2) free water in the cell lumina; and (3) external water on the surface of the particles. This moisture can be removed by (1) natural drying; (2) thermal drying; and (3) mechanical drying. Mechanical drying constitutes the topic of this presentation.

Several types of dewatering equipment are used on an industrial basis today to remove moisture from wood fuel; four major types are commercially available (roll, chain, ram and screw presses). It appears, however, that these are really effective only for very wet material and usually cannot decrease moisture below 100% (50% wet basis).

Research is under way to develop equipment capable of mechanically removing some of the free water present in the wood cells. Mr. John G. Haygreen, Head of the Department of Forest Products at the University of St. Paul, is the leader in compression drying research. His early laboratory work indicates a potential energy gain ratio of 70 when drying small wood samples by compression; at the present time a full scale press capable of reducing moisture content of wood chips down to 50 - 60% is being tested.

FERIC and TVA (Tennessee Valley Authority) have been involved in the testing of a dual roll splitter as part of an ENFOR project. The dual roll splitter is capable of crushing bolts of wood up to 13 cm in diameter. The major conclusions of this project are that roll splitting: (1) effectively defiberizes bolts (specially low density species); (2) achieves only limited dewatering; and (3) greatly accelerates natural drying.

Conclusions

Present dewatering equipment is ineffective for drying material below 100% MC. Laboratory research indicates that compression drying material down to 50 - 60% MC is feasible. Concepts like the roll splitter which take full advantage of natural drying offer interesting potential.

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Some Missing Answers - Syndical Review

MODERATOR: Dr. M. Schneider, University of New Brunswick

This session was introduced by the Moderator as being an expanded opportunity to advance the art and science of chip drying by identifying problems. The participants were separated by random selection into three groups and were counselled to discuss drying based on the presentation and their collective experience.

The objective was to develop a group consensus on a problem which it was felt needed solution in order to progress beyond current practice.

The syndicates, or groups, were composed of 10 participants on average and were arranged as follows:

Syndicate 1 - G. McKenna, facilitator; Thermal Drying subject
Syndicate 2 - S. Vuckovic, facilitator; Thermal Drying subject
Syndicate 3 - D. Guimier, facilitator; Mechanical Drying subject

Each Syndicate spent 30 minutes discussing the assigned subject, agreeing on a problem and designating an agency to solve it. The results were:

Syndicate 1

Problem A. There is an information gap respecting the down-sizing of industrial dryers for the commercial and residential user.

B. There is a need for a dryer which is economically-suited to small-scale consumers.

A. Suggested agency to solve the problem

It was felt that the Energy Secretariat could publish a popular version of current technical handbooks to serve as an initial reference.

B. Suggested agency to solve the problem

Funding through Energy, Mines and Resources Canada was considered to be the most appropriate approach because of past and current success of that agency in developing systems and equipment.

Syndicate 2

Problem: The economic use of wood residues for residential heating with particular reference to collection, distribution and combustion is developing slowly.

Suggested agency to solve the problem

It is felt that the private sector must take the initiative to invest in facilities for processing and marketing wood residues for fuels in residential applications. However, it is inherent in the proffered solution that governmental financing is necessary at the high risk time of early development.

Syndicate 3

Problem A. Effect of roll crushing of logging residuals which are subsequently fed to comminuter and dried naturally needs immediate study.

B. There is no commercial mechanical drying system for residues.

Suggested agency to solve the problem

A. The industrial forest products research facilities - PAPRICAN, FERIC particularly - in cooperation with individual corporations are suggested as the lead agencies.

B. Universities with Forestry faculties were considered best suited to examine further surfactants and dessicants as two possible agents for economic drying.

COMMERCIAL WOOD CHIP DRYING PROJECT

Summary of remarks by Percy Toft, P.Eng.

The Wood Chip Drying project on the Lakeville farm of Percy Toft, P.Eng. is funded by a grant from the Canada/New Brunswick Conservation and Renewable Energy Demonstration Agreement (CREDA). It involves experimental treatment of wood chips from harvesting to drying including storage and handling, with emphasis on practical considerations.

The farmers of Carleton County are ideal users of this technology because they have the equipment, mechanical skills and wood sources required to defray initial start-up costs and to ensure continued savings. Still to be resolved in order for a viable, wood chip industry to be established are readily-available, CSA-approved furnaces, adequate storage and drying facilities and insurance guidelines.

There have been strides forward in these problem areas. For instance, a CSA standard pertaining to wood residue furnaces was released in August.

The problems which this project are addressing concern storage and drying of wood chips. The drier the chips, the more stable they are with respect to chemical reaction. Also, if chips are stored outside, they may deteriorate; and if they are stored inside, they should be treated by ventilating with forced air.

However, in spite of the problems mentioned, burning chips is economically viable based on simple calculations for a year's worth of fuel: 10 tons X $30.00/ton (including drying) = $300.00 as opposed to 4,000 L fuel oil = $1,600.00.

Specifically, the project involves harvesting, drying and storage of wood chips. For chipping, a Bruks 722 is used which produces 1/2" chips that do not require screening. The unit takes its power from a 74 HP tractor with power take-off (PTO) fitted with a torque limiter. Chipping whole trees requires three men to produce one ton/hour as compared to chipping slabs which requires one man to produce one ton/hour. Labour costs for chipping, hauling and off-loading range from $36.33/ton (82 tons) for whole trees to $17.05/ton (25 tons) for slabs, an average of $25.51/ton (Total = 107 tons). Total costs are estimated at $50.00/ton. Moisture content of chips from both whole trees and slabs is 45%.

Chips are removed to storage and drying sites via truck and a modified potato bin piler.

Relative hunidity and air temperature have alot to do with drying chips. The Main Drying Bin received heated air drawn from an adjacent greenhouse which acted as a heat sink. Fans delivered 2,000 CFM of hot, dry air from the greenhouse through the chips in the bin for 25 - 31 days. This required $10.00/ton electric power for 21 - 28 tons. The chips in the Shop Drying Bin received 2,000 CFM of ambient air for 61 days. This method required $8.35/ton electric power for 10.95 tons. The Live Bottom Drying Bin which kept the chips in motion while increasing exposure rate of ambient air received 9,000 CFM for 14 - 27 days at a cost of $10.00/ton electrical power for 3 - 6 ton/load.

Outside, an Ambient Air Drying Bin constructed on stilts relied on natural convection to dry the chips.

In conclusion, existing equipment and structures wll enable farmers to take advantage of these demonstration results.

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